THE STUDY OF LARGE SCALE STRUCTURE

Grant NAGW-201

FINAL REPORT

For the period 01 July 1981 through 30 June 1996

Principal Investigators

Dr. Margaret J. Geller and Dr. John P. Huchra

July 1996

Prepared for
National Aeronautics and Space Administration
Washington, D.C. 20546

Smithsonian Institution
Astrophysical Observatory
Cambridge, Massachusetts 02138

The Smithsonian Astrophysical Observatory
is a member of the
Harvard-Smithsonian Center for Astrophysics

During 1995-6, NAGW-201 provided a small amount of support for our continuing studies of systems of galaxies and large-scale structure (see bibliography below).

The Century Survey is now complete to a *well-calibrated*, somewhat fainter limiting apparent magnitude than we had originally planned ($m_R = 16.1$). Perhaps the most striking result of the survey is the evidence a feature in the power spectrum at a scale of ~ 5000 km s^{-1}; i.e. a "preferred" scale for the voids. From a physical point of view, this scale is particularly interesting: it is approximately the scale of the horizon at the epoch of decoupling.

We have computed a preliminary luminosity function, the spatial correlation function, and the velocity moments. The velocity moments as a function of scale are in striking agreement with the CfA+SSRS2 results. Although the Century Survey contains one-tenth the number of galaxies in the CfA+SSRS2, it samples a comparable number of large (~ 5000 km/s) structures. For this reason (along with the better galaxy positions and well-calibrated magnitudes), the velocity moments are well constrained. We plan to publish analyses and the data for the Century Survey within the next year.

To investigate some of the scientific issues raised by analyses of the CfA, SSRS2, and Century surveys (see e.g. Marzke *et al.* 1995), we have nearly completed a survey complete to $m_R = 15.4$ (15R survey) over $\sim$1000 square degrees. The striking preliminary maps again show well-defined scale of $\sim 5,000$ km/s for the largest voids. The survey also indicates that, as suggested by recent analyses of the LCRS survey, there is modulation of the structure on a scale of $\gtrsim 100$ Mpc. We plan to submit a first paper this fall.

We have nearly completed the process of obtaining arcsecond coordinates for all of the galaxies in the CfA redshift survey. These coordinates will enable the *first* computation of the pairwise velocity dispersion for the galaxy distribution (Marzke *et al.* 1995) on scales of 100 kpc and smaller. The small-scale pairwise dispersion is a measure of the importance of (1) the dynamical state of systems and (2) the "softness" of galaxy-galaxy interactions (Diaferio and Geller 1996). This new study complements Barton's recently completed work on selection of compact groups from redshift surveys (Barton *et al.* 1996).

Direct distance measurements enable more direct studies of large-scale dynamics. We have completed an IRTF investigation of the velocity field in the vicinity of the Great Wall (Dell' Antonio *et al.* 1996a, b). We derived the first limits on the spatial thickness of the Wall ($\lesssim 11h^{-1}$ Mpc) and thus demonstrate that the Great Wall is indeed a thin 2D structure in real as well as in redshift space. We also show that there is minimal shear across the extent of the Great Wall. We plan to continue this project when the Arecibo upgrade is completed this fall; we should be able substantially better physical constraints on the properties of the Great Wall and on large-scale flows on the 10,000 km/s scale.

We also continued to study groups (Ramella *et al.* 1995 a,b; Diaferio *et al.* 1995;

Dell' Antonio *et al.* 1996) and clusters of galaxies (Mahdavi *et al.* 1996). Mohr *et al.* (1995) extendend their examination of the cluster morphology-cosmology connection. They are in the process of investigating how optical data improve the constraints imposed by x-ray observations (Mohr *et al.* 1996a, b).

BIBLIOGRAPHY

1995 "The Redshift Neighborhoods of Groups of Galaxies I. The Data", M. Ramella, M.J. Geller, J.P. Huchra, and J.R. Thorstensen, *A. J.*, **109**, 1458.

1995 "The Redshift Neighborhoods of Groups of Galaxies II. Analysis", M. Ramella, M.J. Geller, and J.R. Thorstensen, *A. J.* **109**, 1469.

1995 "Pairwise Velocities of Galaxies in the CfA and SSRS2 Redshift Surveys," R. O. Marzke, M. J. Geller, L. N. da Costa, and J. P. Huchra, *A. J.*, **110**, 477.

1995 "The Formation of Compact Groups of Galaxies. II. X-Ray Properties", A Diaferio, M.J. Geller, and M. Ramella, *A.J.*, **109**, 2293.

1995 "Recent Evolution in Cluster Velocity Dispersions", M.M. Crone and M.J. Geller, *Ap.J.*, **110**, 21.

1995 "Redshifts for Fainter Galaxies in the First CfA Slice III. To the Zwicky Limit" J.R. Thorstensen, M.J. Kurtz, M.J. Geller, F.A. Ringwald, and G. Wegner, *A.J.*, **109**, 2368.

1995 "The Evolution and Large-Scale Structure of the Universe", *Enciclopedia del Novecento*, (Istituto della Enciclopedia Italiana: Roma), in press

1995 "Cosmological Constraints from Cluster X-Ray Morphology," J. Mohr, A. Evrard, D. Fabricant, and M.J. Geller, *Ap. J.*, **447**, 8.

1995 "The CfA Redshift Survey: Data for the NGP +36 Zone," J.P. Huchra, M.J. Geller, and H. J. Corwin, *Ap. J. Suppl.*, **99**, 391.

1995 "A Photometric Survey in Slow-Drift Scan Mode of the Cor Bor Supercluster", M. Ramella, M. Nonino, M.J. Geller, S. Kent, *Mem. S. A.*, **66**.

1995 "Baryon Fractions for Poor Clusters of Galaxies", I. P. Dell'Antonio, M. J. Geller, D. G. Fabricant, *A. J.*, **110**, 502.

1996 "The Lumpy Cluster A1185", A. Mahdavi, M.J. Geller, D.G. Fabricant, M.J. Kurtz, M. Postman, and B. McLean, *A.J.*, **111**, 64.

1996 "The Redshift Neighborhoods of 13 SSRS Groups of Galaxies", M. Ramella, P. Focardi, and M.J. Geller, *Astron. Astrophys.*, in press.

1996 " Galaxy Pairwise Velocity Distributions on Non-Linear Scales", A. Diaferio and M.J. Geller, *Ap. J.*, in press.

1996 " A 576: An Optical and X-Ray Study of a Galaxy Cluster with a Cold Core", J.J. Mohr, M.J. Geller, D.G. Fabricant, G. Wegner, J.R. Thorstensen, and D.O. Richstone, *Ap. J.*, in press.

1996 "The Rotation Velocity-Density Relation", L.A. Allen and M.J. Geller, *A.J.*, in press.

1996 "Peculiar Velocities for Galaxies in the Great Wall: The Data," I. Dell' Antonio, G.D. Bothun, and M.J. Geller, *A.J.*, in press.

1996 "Peculiar Velocities for Galaxies in the Great Wall: The Analysis," I. Dell' Antonio, M.J. Geller, and G.D. Bothun, *A.J.*, in press.

1996 "Compact Group Selection from Redshift Surveys", E. Barton, M.J. Geller, R.O. Marzke, M. Ramella, and L. N. da Costa, *A.J.*, in press.

1996 " Groups of Galaxies in the Northern CfA Redshift Survey," M. Ramella, A. Pisani, and M.J. Geller, *A.J.*, submitted.

1996 " Large Scale Structure at Low Galactic Latitude," R.O. Marzke, J.P. Huchra, and M.J. Geller, *A.J.*, in press.

1996 "Dynamics of the Poor Galaxy Clusters Abell 2626 and Abell 2440", J.J. Mohr, M.J. Geller, and G. Wegner, *A.J.*, submitted.